Helix/Separator Project Overview

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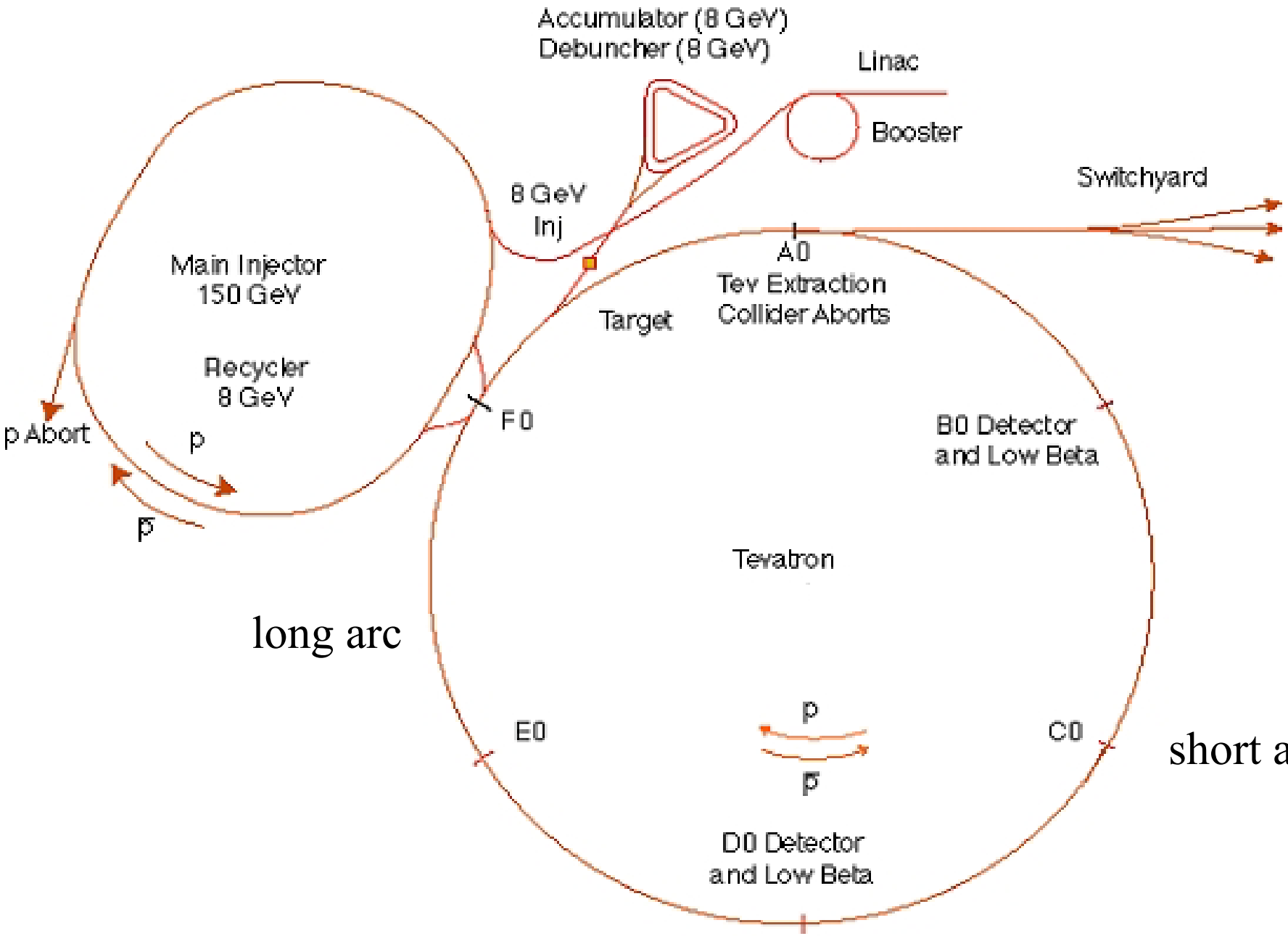
Helix / Separator Project

- Reduce damaging beam-beam effects throughout all phases of Tevatron operation (injection, ramp, squeeze, colliding beams) by increasing beam-beam separation
- Modify helical orbits, i.e. how we use our separators, to maximize separation up to physical, dynamic aperture limitations
- Install additional (existing design) separators to provide more kick
- Design, build longer separators around IPs
- Obtain higher gradient by coating separators
- Construct additional polarity switches for supplies

FermilabTevatron Accelerator With Main Injector



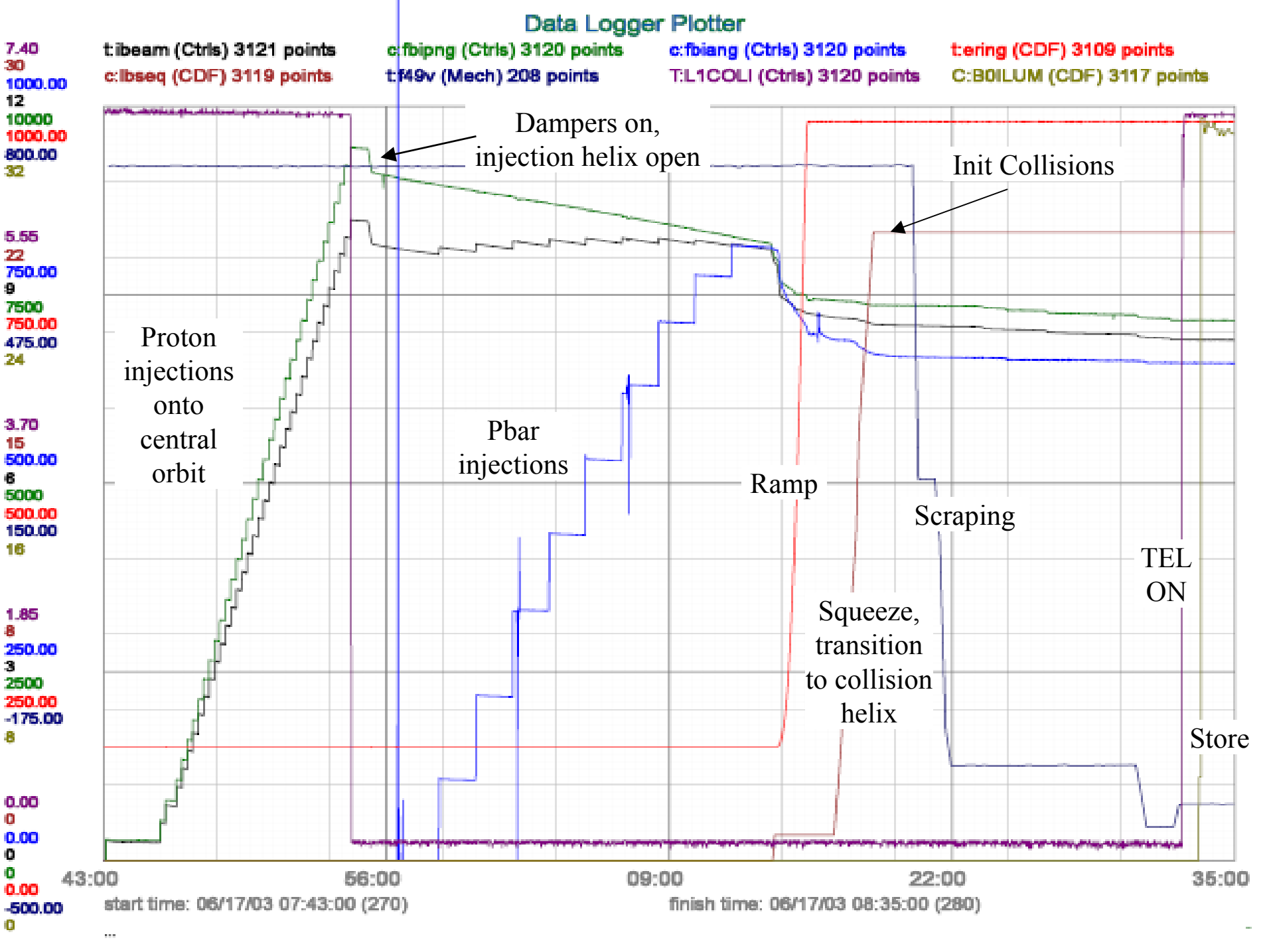

Data Logger Plotter
t:ibeam (Ctrls) 3121 points
c:fbipng (Ctrls) 3120 points
c:fbiang (Ctrls) 3120 points
t:ering (CDF) 3109 points
c:lbseq (CDF) 3119 points
t:f49v (Mech) 208 points
T:L1COLI (Ctrls) 3120 points
C:B0ILUM (CDF) 3117 points
Dampers on, injection helix open
Init Collisions
Proton injections onto central orbit
Pbar injections
Ramp
Scraping
TEL ON
Squeeze, transition to collision helix
Store
43:00
56:00
09:00
22:00
35:00
start time: 06/17/03 07:43:00 (270)
finish time: 06/17/03 08:35:00 (280)

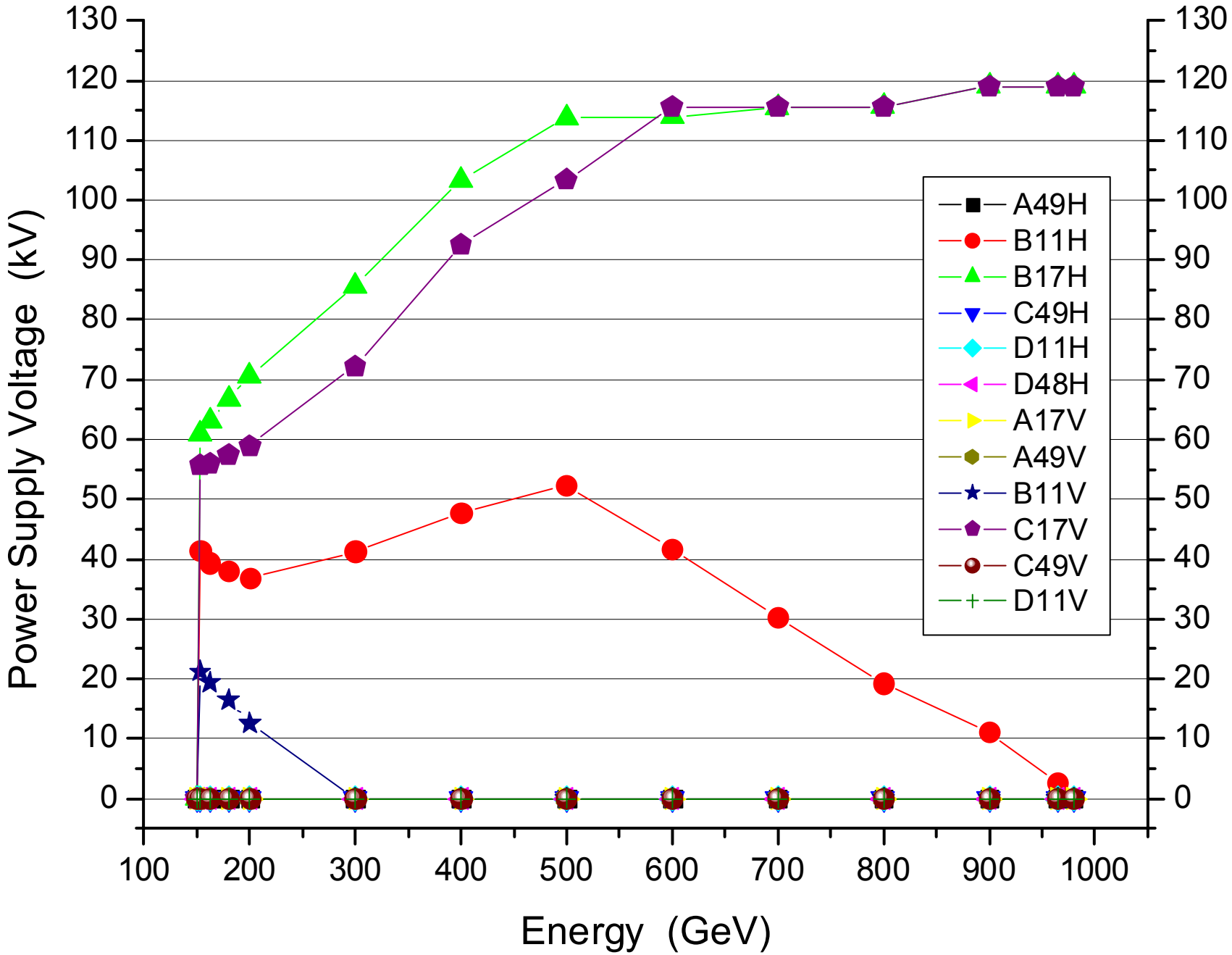
Table of Separator Locations

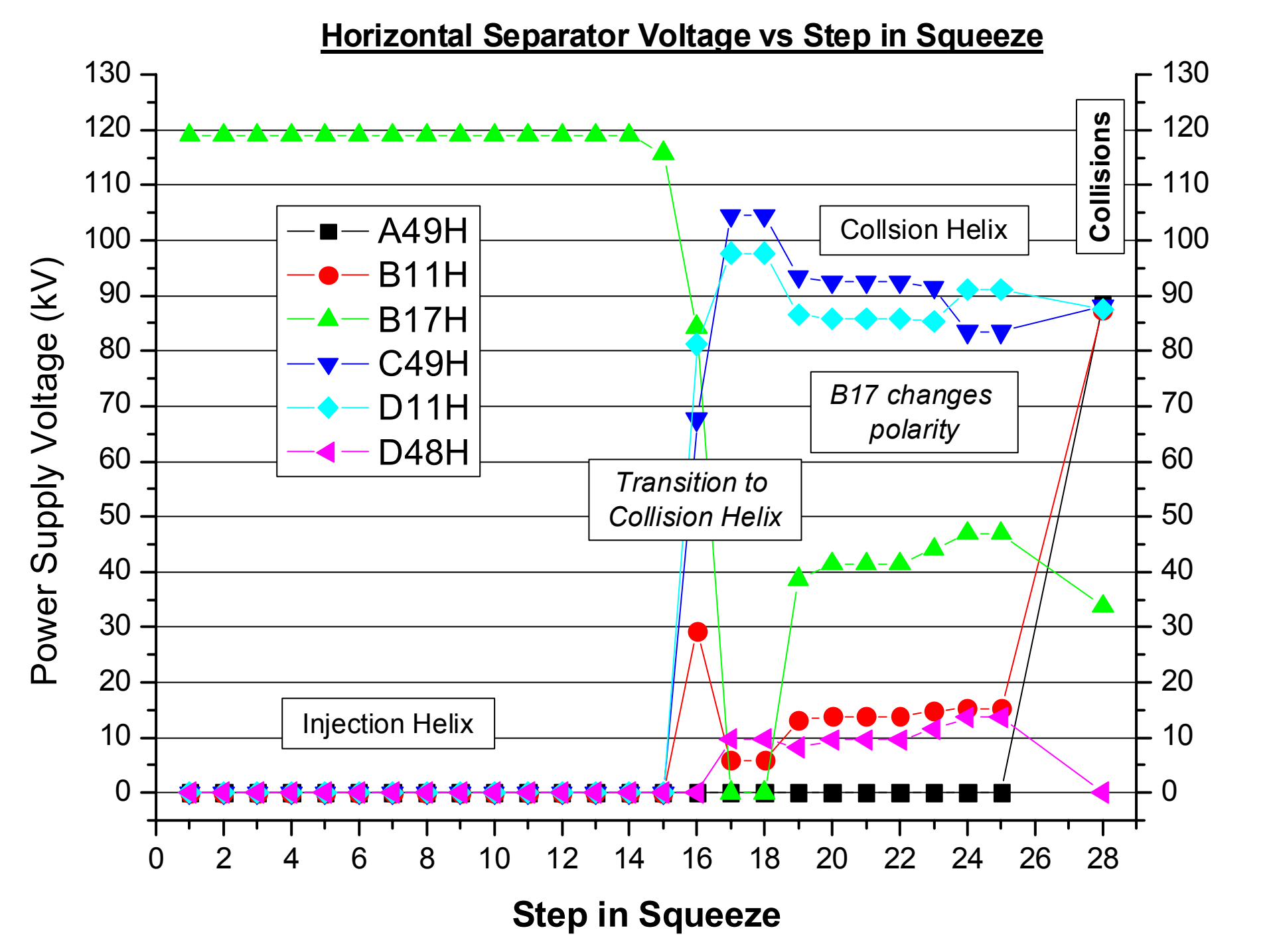
Horizontal	# modules	Polarity Switch?	Vertical	# modules	Polarity Switch?
			A17	1	No
A49	1	No	A49	2	No
B11	2	Yes	B11	1	Yes
B17	4	Yes			
			C17	4	Yes
C49	1	No	C49	2	Yes
D11	2	No	D11	1	No
D48	1	No			

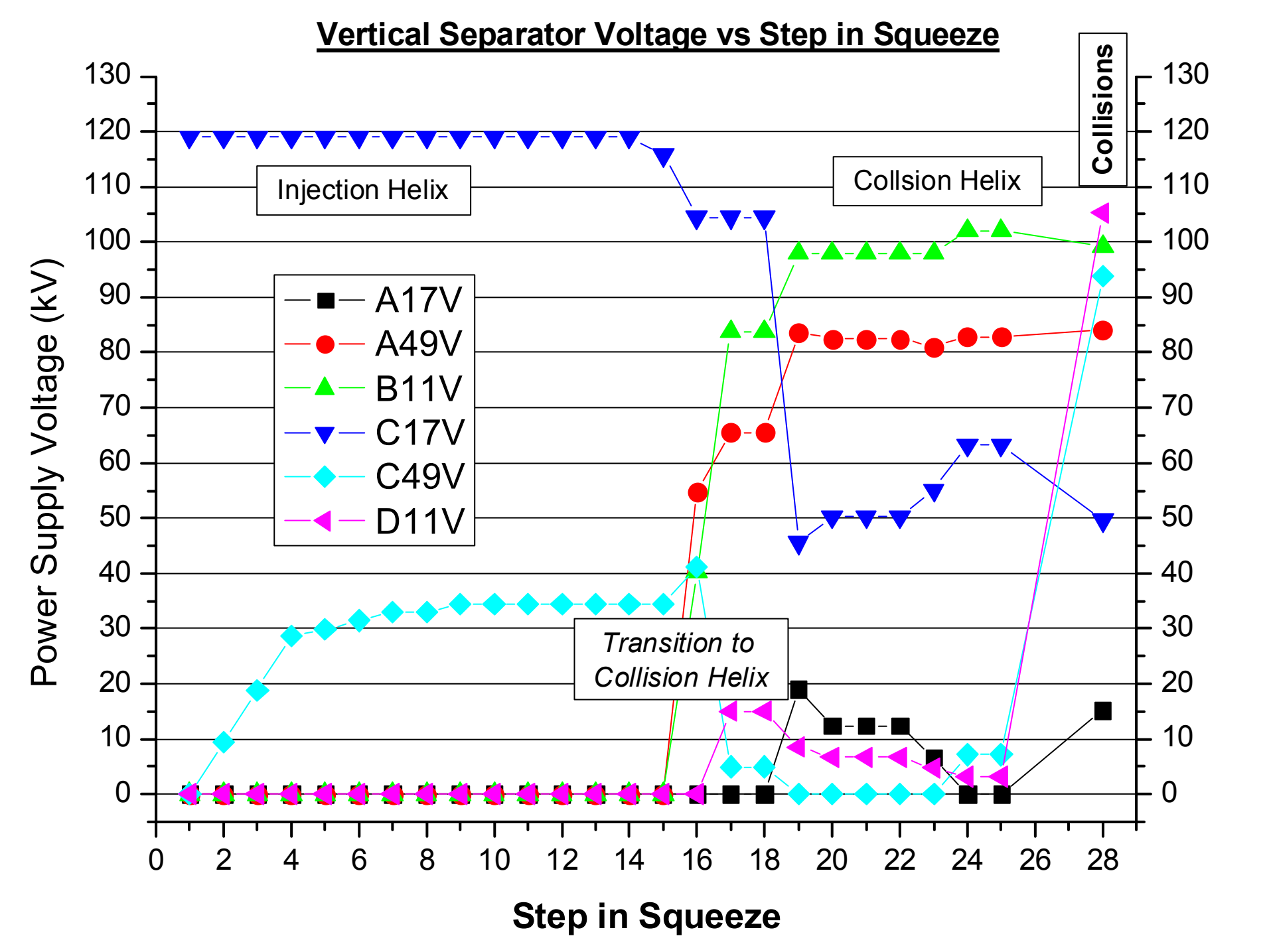
Total: 22 separator modules + 8 spares (4 not yet conditioned)
5 polarity switches + 1 spare (torn apart)

Injection, Collision Helix Generalities

- Injection Helix
  - Horizontal orientation set by pbar position at injection lambertson
  - Beam separation limited by physical, dynamic aperture @ 150 GeV
  - Beam separation decreases above 500 GeV when separator voltage reaches maximum
- Collision Helix
  - Horizontal orientation set by pbars being to inside at D0; opposite from injection helix
  - No physical aperture limitations
- Transition from Injection → Collision Helix
  - Occurs during the squeeze
  - Beam separation decreases uncomfortably as B17H separator changes polarity


Separator Voltage vs Energy Up Ramp
Power Supply Voltage (kV)
Energy (GeV)
A49H
B11H
B17H
C49H
D11H
D48H
A17V
A49V
B11V
C17V
C49V
D11V


Horizontal Separator Voltage vs Step in Squeeze
Power Supply Voltage (kV)
Step in Squeeze
A49H
B11H
B17H
C49H
D11H
D48H
Collsion Helix
Collisions
B17 changes polarity
Transition to Collision Helix
Injection Helix
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28


Vertical Separator Voltage vs Step in Squeeze
Collisions
Injection Helix
Collsion Helix
A17V
A49V
B11V
C17V
C49V
D11V
Transition to
Collision Helix
Power Supply Voltage (kV)
Step in Squeeze
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28

Brief Description of Separator Modules

- 1-4 individual modules in series make up a “separator”
- 257 cm long stainless steel electrodes
  - 297 cm total “slot length” (space needed in tunnel)
- 5 cm gap between electrodes
- Bipolar operation
- Conditioned at 150 kV, typically run 115-120 kV max
- Can bake at 150-200°C in situ
- Attached 220 L/s ion pump, pair of Ti sublimation pumps

Def'n of Beam-Beam Separation

- Yuri and John have used slightly different definitions of size, beam separation
- Radial separation = distance between beams in units of beam sigmas

Yuri

$$\sigma_{x,y} = \sqrt{\beta_{x,y}\varepsilon_{rms}}$$

$$\sigma_s = \sqrt{\frac{d_x^2}{\sigma_x^2} + \frac{d_y^2}{\sigma_y^2}}$$

$$\varepsilon_{rms} = 15\,\pi\ mm \cdot mrad$$

John

$$\sigma(\mathrm{E}) = \sqrt{\beta\varepsilon_{95}/6\gamma + \left(\eta\delta_{95}(\mathrm{E})/2\right)^2}$$

$$\sigma_s = 2 \cdot \sqrt{\frac{d_x^2}{\sigma_x^2} + \frac{d_y^2}{\sigma_y^2}}$$

$$\varepsilon_{95} = 20\pi\ mm \cdot mrad$$

- For future uniformity, I'll try to convince one to use the other's convention

Helix/Separator Strategy

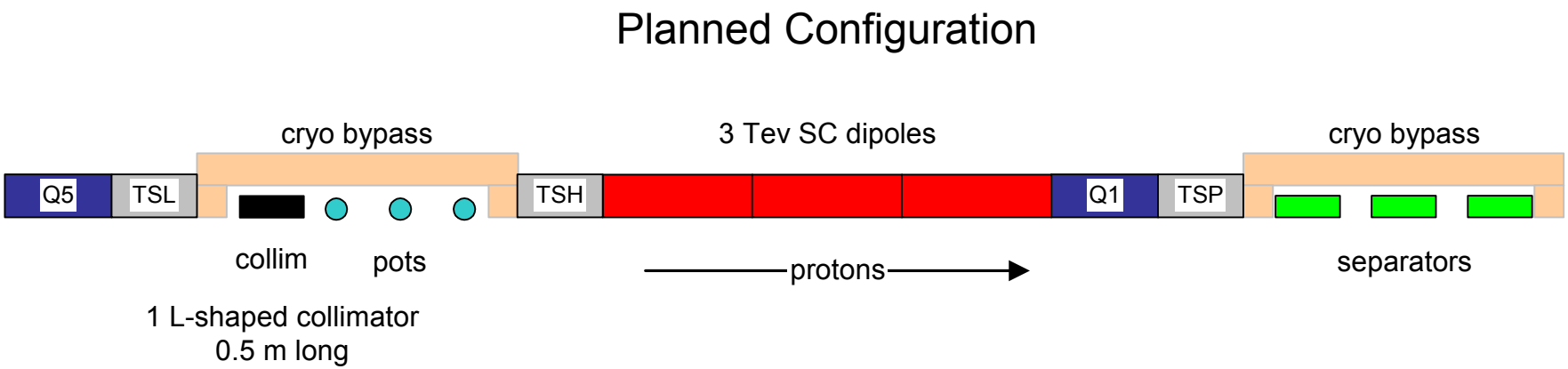
- What we can do / are doing now
  - Increase beam-beam separation > 500 GeV
  - Increase separator voltages, exploit unused separators
  - Yuri will discuss this topic
- What we can do with additional (spare) separators
  - Have 4 spares now, want to build 4 more
  - Install spares (where practical) to provide more kick
  - John Johnstone will discuss
- What we can do with NEW separators
  - Longer separators at IPs
  - Higher gradient separators with electrode coating?
  - John Johnstone will discuss

New Longer Separators Around IPs

- Longer separators would be ≈20% longer than current
- To make space for longer seps
  - Remove unused Q1 quads around B0
  - Remove Roman Pots (diffractive physics) around D0
    (Q1's around D0 already removed to install Pots)
- Makes no sense to install longer seps around only 1 IP
- Would construct 14 separators…3 on each side of the 2 IPs + 2 spares
- Need a strong case to proceed before asking D0 to give up part of their physics program

A48/A49 Configuration

After the Sep/Oct 03 shutdown, this A48/A49 will look like this…



Polarity Switches

- Only 5 separator supplies have switches…want more
  - For more flexibility with possible helix solutions
  - To allow protons to be put on pbar helix entire way through squeeze (for tuning up)

- Switches made in TD
  - Project to build (?) more deferred for lack of $$
  - Should get the $$, start building them (~14 k$ each)

- A design flaw recently discovered…should be remedied before constructing new switches

Other Items to Pursue

- Reduce beam-beam effect by running 18×18
  - Looks good from simulations
  - Impact of additional interactions/crossing on detectors?
- Implement crossing angle at IPs
  - Never(?) intentionally tried
  - Effect of going off-center through low-β quads?
- Reduce β* from 35 cm to 25 cm?
  - Need the Q1 magnets…could only be done at B0 at present
  - If longer seps installed at B0, can't do it at all

Collimators

Proton	Orientation	Used for HEP	Pbar	Orientation	Used for HEP
D49 (target)	⌝	*	F49 (target)	⌝	*
E0-3	⌝	*	F48	⌟	*
F17-2	⌝	*	D17-2	⌝	*
D17-1 (target)	⌞		F17-3 (target)	⌞	
D17-3	⌞		F17-1	⌞	
E0-1	⌞		E0-2	⌞	
A11	⌞	*			
A48	⌞	To be installed			

- 2-stage collimation system; 5 mm thick targets, 1.5 m long (most) L-shaped stainless steel secondaries
- Steel orientation as viewed in proton direction: ⌝ = inside, up ⌟ = inside, down ⌞ = outside, down
- If collision helix orientation changed, could rotate/flip collimator steel without much difficulty